524875

N91-10576

41

(13)

Space Station

Judith Hayes, M.S.
Technology Life Sciences Division
Krug International
Houston, Texas

and

Don Stewart, M.D.
Medical Operations Branch
NASA Lyndon B. Johnson Space Center
Houston, Texas

Introduction

The concept of Space Station is not new. Even excluding the romantic vision of early writers, there is a rich heritage of space station engineering designs that predate the origin of the National Aeronautics and Space Administration (NASA) in 1958. These designs have advanced concurrently with the evolution of science and technology, as well as in response to historical and political circumstances.

Space station proposals generated in the early 1900's were very progressive, incorporating modular architectural structures, solar power, and simulated gravity from rotating habitable elements. The purposes of such designs have remained common: (1) celestial observation of the cosmos, (2) global communication, (3) manned Earth-orbiting service for interplanetary exploration, (4) research in a microgravity environment, and (5) military defense.

Technology spinoffs from World War II provided important contributions to space science through advances in ballistics and rocketry and thereby inspired a postwar plethora of new designs for space station. These designs were more sophisticated and included such capabilities as physiological/psychological research on space personnel, radio wave reflection/refraction studies, solar radiation and cosmic-ray investigations, orbital deployment, and simulated-gravity research. The scientific community and public opinion gradually persuaded the Congress of the United States to commit to increased support of basic research and applied science for the advancement of commerce and industry. Accordingly, in 1958, legislation created NASA with the intent to expand human knowledge and lead toward the development and operation of vehicles capable of transporting equipment, supplies, and living organisms through space. Scientists and engineers began preliminary space station studies at the NASA Langley Research Center (LaRC) in 1959, evaluating space station concepts that would best serve space exploration and interplanetary travel. Many of the space station proposals put forth by NASA incorporated concepts that were evident in earlier designs.

In 1961, when President John F. Kennedy declared that we should go to the Moon by the end of the decade, many assumed that a space station in Earth orbit would be the logical prelude to a manned lunar landing. However, the agency decided on a lunar-orbit rendezvous (Apollo) that would make it unnecessary to utilize a space station as a staging and servicing base for an Earth-lunar flight, thus diverting most of NASA's resources to the Apollo Program. At that time, emphasis on the function of space station changed from an orbiting launch site to an orbital research facility, and this change altered the requirements which would drive the space station design.

Although some space station work continued at the NASA Manned Spacecraft Center (MSC) in Houston and the NASA George C. Marshall Space Flight Center (MSFC) in Huntsville, Alabama, most of the effort was concentrated at the LaRC in Virginia. From 1963-69, NASA's space station concept was considered "a research center for space" and labeled the Manned Orbiting Research Laboratory (MORL). During this era, space science increased in magnitude and broadened the spectrum from astronomy and astrophysics to geology, oceanography, biology, physiology, chemistry, nuclear physics, and materials science. In 1963, the Department of Defense initiated the Manned Orbiting Laboratory (MOL) for the purpose of determining man's military efficacy in space. This system consisted of a modified Gemini spacecraft which would rendezvous and dock with a cylindrical laboratory. Each component would be separately launched on a Titan III rocket.

Despite the demands of the Apollo Program, some space station studies did continue at MSC and MSFC. The MSFC studies focused on an unmanned platform derived from the Saturn V spent propulsion rocket stage, termed the Spent Stage Workshop. Meanwhile, the MSC concentrated on manned operations characterized by a "Y" configuration spacecraft that included three radial arms, which would be launched by a two-stage Saturn V and would provide living and working accommodations for a crew of 24. By 1965, NASA's Office of Manned Space Flight (OMSF) considered ways to utilize its capabilities developed for the Apollo missions in an "Apollo Applications Program." Concomitantly, in 1966, NASA initiated an agency-wide space station effort that attempted to obtain the approval of the President. In 1969, the President's Space Task Group failed to support space station as a necessary portion of NASA's development plan and it became the victim of an effort to contain the Federal budget. The Space Shuttle, a reusable space vehicle, did win the approval of the administration, and NASA continued to investigate the feasibility of a manned space station through the Apollo Applications Program under the guise of Skylab.

In 1973, four successive Skylab missions were conducted, placing into low Earth orbit a laboratory and three separate three-man crews to conduct experiments for record-breaking durations: 28, 59, and 84 days, respectively. Skylab was utilized as a research facility, incorporating the Apollo telescope mount (ATM), Earth observation research, and extensive medical studies. Skylab reinforced the notion that indeed man did have a significant function in the future of long-duration space research and exploration.

Following the success of Skylab, NASA phased out the Apollo and Saturn Programs and emphasized the development of the Space Transportation System (STS) with the Space Shuttle. The capabilities of the Space Shuttle and rapid advancements in both ground-based and space-based technology presented new opportunities for developing space systems for practical use. Once the Space Shuttle system was proved successful, the emphasis was shifted toward the construction of a large manned space vehicle. In 1976, "space industrialization" was the new concept and generated some new space station designs which would ultimately incorporate the Space Shuttle Orbiter for servicing and supply. In 1977, NASA announced that the Space Construction Base would begin development in 1980 and be prepared for initial use in 1985; however, neither the exiting administration (Ford) nor the incoming Carter administration would request in the 1978 fiscal year budget the $15 million essential for preliminary space station studies. Thus, the space station effort ceased until 1979, when the NASA Lyndon B. Johnson Space Center (JSC), formerly the Manned Spacecraft Center, in Houston resumed work with a study of the Space Operations Center (SOC). Following a preliminary definition study for the SOC, NASA announced that a permanently manned space station would be the next major venture into space, and established the Station Technology Steering Committee. Finally, an agency-wide space station effort began in earnest. In the State of the Union address of 1984, President Ronald Reagan directed NASA to develop a permanently manned Space Station within the decade. This directive underscored an initiative for the United States to maintain its leadership in space.

Description

Space Station will represent the beginning of a permanent presence in space for the United States. Current plans consist of a manned base and two or more unmanned free-flying platforms. The station will be positioned in low Earth orbit at about 250 miles altitude, at an inclination of 28.5° to the Equator. Once manned, the Space Station will initially support a crew of eight, with crew rotations and resupply from the Space Shuttle Orbiter at 90- to 120-day intervals.

The initial operating configuration will be approximately a 350-foot towerlike structure that includes two logistics modules, four pressurized cylindrical modules, a power system, a propulsion system, attached pallets, a robotics system, and a communications system. These elements will be linked by a trusswork in a single-keel configuration. This configuration provides space for attachment of payloads and accommodates future expansion. Ultimately, the goal of Space Station is to provide a modular-evolutionary design that permits growth, accepts modern technology, and will have an indefinite life through in-flight repair, maintenance, and/or hardware substitution.

The components of the Space Station will be fabricated on Earth to fit into the cargo bay of the Orbiter and launched in segments for construction on orbit. Assembly of the Space Station will take place over a period of several years utilizing robotic devices and possibly the manned maneuvering unit (MMU) to assemble all of its elements. Upon initial assembly, the Space Station will weigh approximately 300 000 pounds. Because of the Space Station experiment requirements, the most satisfactory location for the pressurized modules will be near the center of the single keel (i.e., the Space Station center of gravity). To provide ease of access and operation, these modules are organized in a raft pattern conjoined by four external resource nodes. The nodes also house some of the subsystems (e.g., the exercise subsystem), while serving as a docking and berthing port for the Space Shuttle.

The four pressurized modules are cylindrical with dimensions of approximately 45 feet in length by 15 feet in diameter. Each of these modules will be internally equipped to function as either a laboratory or living quarters for the crews of the Space Station. The Space Station provides a comfortable, functionally efficient habitat that will support a crew living and working together for durations of 90 to 120 days. Ergonometric consideration has been given to crews from the 5th-percentile female to the 95th-percentile male; thus, the "average" crewmember should find the architectural elements comfortable.

The United States will provide two of the pressurized modules: the Habitation Module and the U.S. Laboratory Module. The European Space Agency (ESA) and Japan will each supply one pressurized laboratory module. The Habitation Module incorporates private crew quarters, a wardroom, a galley, and the fundamental health and recreational needs of a crew. The U.S. Laboratory Module will be used for materials research, manufacturing, and life sciences research. The Japanese Experiment Module (JEM) will provide a multipurpose research and development laboratory that will also include a local remote manipulator arm, an experiment logistics module, and an attached work deck for mounting payloads requiring direct exposure to space. Meanwhile, the ESA Module has a life sciences and materials research laboratory, a polar platform, and a co-orbiting platform. In keeping with the long-term policy of international cooperation, Canada will furnish a Mobile Servicing Center that will provide the remote manipulator system, end effectors, servicing tools, control stations, and special-purpose manipulators.

The Space Station atmosphere will be maintained by the environmental control and life support system (ECLSS). The ECLSS is a "closed-loop system" that recycles oxygen and water. This system will supply the crew with breathable air and with water for ingestion and bathing, remove contaminants from the module atmosphere, and process biological wastes. It will only be necessary to resupply the station periodically with food and nitrogen. Energy will be generated by integrating both photovoltaic and solar dynamic systems. These power modules are mounted on the tips of the single-keeled trusswork and provide a hybrid power system for the Space Station.

The United States will provide two logistics modules for resupply of Space Station consumables, storage of spare hardware, and stowage of wastes. An onboard automated logistics subsystem will assist the crew in tracking supplies, identifying trends, and predicting resupply requirements. Payloads requiring minimum disturbance and protection against contamination will be accommodated by the unmanned platforms. The Space Station crews will undertake the retrieval and deployment of the platforms into their assigned orbits and attitudes, as well as the payload servicing, repair, checkout, operations, removal, and/or replacement.

Space Station capabilities will be enhanced by the utilization of several new space transportation vehicles being developed. The manned maneuvering unit, already employed on Space Shuttle missions, consists of a self-contained backpack propulsion device that allows a crewmember to venture untethered into space. It is expected that the MMU will assist in conducting scientific research, assembling structures, and executing rescue operations in space. The orbital maneuvering vehicle (OMV), described as a "smart space tug," will be used to transport payloads between low Earth orbit trajectories. The OMV will have the potential to deliver expendable supplies to satellites, transfer crewmembers to satellites for maintenance, and move payloads from the Space Shuttle to the station. Eventually, an orbital transfer vehicle (OTV) will be incorporated into the program allowing transport of payloads from low Earth orbit to higher energy orbits, including geosynchronous transfer, ellipse, and Earth escape trajectories. Initially, the OTV will be unmanned; however, ultimately, this vehicle will be developed into a crew transport and have the capacity for boost into high-velocity orbits supporting interplanetary travel.

It is anticipated that the astronaut corps will be separated into groups for the station era, including both Space Shuttle and Space Station cadres. Both groups will share similar training initially, but much of their training will be specific to either Space Shuttle or Space Station. The Space Station astronaut corps will consist of fewer than 100 and will be further classified as operators and scientists. It is estimated that 36 months of basic station training will be necessary for the crewmembers, as well as an additional 18 months of mission-specific training. These recommendations have been based on an eight-man crew and a 90-day crew rotation, with eight Space Shuttle missions per year transporting four new crewmembers each trip. The crew will consist of a minimum of 8 persons and will eventually be increased to 18 crewmembers. Each crew will include at least two crewmembers with detailed knowledge of the Space Station systems operations and maintenance (Station Operators). The other crewmembers will primarily support user mission objectives (Mission Specialists and Payload Specialists). Each crew will operate on two 12-hour shifts, with one Station Operator on each shift. The scheduled work week for every crewmember will be 6 days. Mission durations will range from 90 to 180 days and may actually persist for as long as 120 or 150 days.

The First Element Launch (FEL) for Space Station is intended for January 1994, whereas the Man-Tended Capability (MTC) will occur 1 year later, in January 1995. The MTC incorporates the assembly of the U.S. Laboratory Module and its outfitting. The Habitation Module will be deployed in April 1995, but the Permanently Manned Phase (PMP) will not occur until the following August. The initial Space Station assembly will be completed in 1996; however, it should continue to grow in both size and capability since it is intended to operate for several decades.

Conclusion

The history of American space flight indicates that a space station is the next logical step in the scientific pursuit of greater knowledge of the universe. The Space Station and its complement of space vehicles, developed by NASA, will add new dimensions to an already extensive space program in the United States.

Space Station offers extraordinary benefits from a comparatively modest investment (currently estimated at one-ninth the cost of the Apollo Program). The station will provide a permanent multipurpose facility in orbit necessary for the expansion of space science and technology. It will enable significant advancements in life sciences research, satellite communications, astronomy, and materials processing. Eventually, the station will function in support of the commercialization and industrialization of space. Also, as a prerequisite to manned interplanetary exploration, the long-duration space flights typical of Space Station missions will provide the essential life sciences research to allow progressively longer human staytime in space.

Bibliography

O'Leary, B.: Project Space Station. Stackpole Books (Harrisburg, Pa.), 1983.

Space Station Program: Definitions and Requirements. Rep. JSC-30000, NASA Lyndon B. Johnson Space Center (Houston, Tex.), Oct. 1985.

Space Station Program: Description, Applications, and Opportunities. Noyles Publications (Park Ridge, N.J.), 1985.

Space Applications Board, Commission on Engineering and Technical Systems, National Research Council: Practical Applications of a Space Station. National Academy Press (Washington, D.C.), 1984.

Civilian Space Stations and the Future in Space. Rep. OTA-STI-241, U.S. Congress, Office of Technology Assessment, Nov. 1984.